TOTAL MAXIMUM DAILY LOAD ASSESSMENT

Mainstem of un-named tributary to Willow Creek from the Willow Creek Reservoir Road to the confluence with Willow Creek

Grand County, Colorado

TMDL SUMMARY	
Waterbody Name/Segment Number	Mainstem of un-named tributary to Willow Creek from the Willow Creek Reservoir Road to the confluence with Willow Creek, COUCUC06C
Pollutant/Condition Addressed	Ammonia
Affected Portion of Segment	All
Use Classification	Aquatic Life Cold 2, Recreation 2, Agriculture
Waterbody Designation	Use Protected
Water Quality Target	Specific decreased monthly loads of total ammonia from the wastewater treatment plant discharging to Segment 6b
TMDL Goal	Attainment of chronic and acute unionized ammonia standards at top of Segment 6c

EXECUTIVE SUMMARY

Section 303(d) of the federal Clean Water Act requires states to identify water bodies or stream segments that are water quality limited on the 303(d) List. Once listed, the State is required to quantify the amount of a specific pollutant that a listed water body can assimilate without violating applicable water quality standards and to apportion that allowable quantity among the different pollutant sources. This maximum allowable pollutant quantity is referred to as the Total Maximum Daily Load (TMDL).

Segment 6c of the Upper Colorado River Basin, the mainstem of un-named tributary to Willow Creek from the Willow Creek Reservoir Road to the confluence with Willow Creek, was included on the 1998 303(d) List as partially supporting due to the existing temporary modifications of the ammonia standard (WQCC 1998).

The Three Lakes Water and Sanitation District (District) wastewater treatment plant (WWTP) discharges treated municipal wastewater near the top of the un-named tributary. Sources of ammonia in the watershed include the wastewater treatment plant discharge (point source), animal waste from grazing cattle and occasional wildlife (nonpoint source) and decomposing plant life. The nonpoint source contributions could be considered negligible (less than one percent of total new load) when compared to the contributions from the WWTP discharge. The only significant source of ammonia is from the WWTP. The TMDL will be implemented in the form of a District discharge permit limit for total ammonia.

I. INTRODUCTION

Section 303(d) of the federal Clean Water Act requires states to identify water bodies or stream segments that are water quality limited. Those water quality limited segments currently identified in Colorado are identified in the 1998 303(d) List. Water quality limited segments are those water bodies or stream segments which, for one or more assigned use classifications or standards, the classification or standard is not fully achieved. Once listed, the State is required to quantify the amount of a specific pollutant that a listed water body can assimilate without violating applicable water quality standards and to apportion that allowable quantity among the different pollutant sources. This maximum allowable pollutant quantity is referred to as the Total Maximum Daily Load (TMDL). The TMDL is comprised of the Load Allocation (LA) which is that portion of the pollutant load attributed to natural background or the nonpoint sources, the Waste Load Allocation (WLA) which is that portion of the pollutant load associated with point source discharges, and a Margin of Safety (MOS). The TMDL may also include an allocation reserved to accommodate future growth. The TMDL may be expressed as the sum of the LA, WLA and MOS.

Segment 6c of the Upper Colorado River Basin, the mainstem of un-named tributary to Willow Creek from the Willow Creek Reservoir Road to the confluence with Willow Creek, was included on the 1998 303(d) List as partially supporting due to the existing temporary modifications of the ammonia standard (WQCC 1998). The temporary modification for ammonia, both acute and chronic, is set at ambient levels and will expire on December 30, 2000. The underlying standard is Table Value Standards (TVS) for acute conditions and 0.02 milligram per liter (mg/L) as Nitrogen (N) for chronic conditions.

Site Description: The un-named tributary to Willow Creek is located in the montane region of north central Colorado in Grand County. This tributary enters Willow Creek approximately 1.5 miles below the Willow Creek Reservoir Dam and is approximately five miles north of Granby, Colorado. Willow Creek enters the Colorado River approximately 5 miles below Lake Granby. The small watershed is dominated by hay meadows and used primarily for cattle grazing. The upper portion of the valley has a poorly defined stream channel and irrigation ditches convey water across the valley. The Willow Creek Reservoir Road crosses the watershed approximately one quarter of the way upstream from the confluences with Willow Creek. Near this road, flows coalesce and form a defined channel. The scope of this TMDL includes the area draining to the un-named tributary and the un-named tributary from its source to the confluence with Willow Creek (Segments 6b and 6c). The watershed (approximately 4 square miles) is part of the Colorado Headwaters Hydrologic Unit Code 14010001. Locational and site maps are included as Figures 1 and 2.

The upper portion of this un-named tributary to Willow Creek is included in Segment 6b of the Upper Colorado River Basin. Segment 6b is classified as aquatic life class 2, but has no numeric standards except for dissolved oxygen (DO), pH and fecal coliform. Segment 6c, the subject of this TMDL, is classified as aquatic life class 2 and has a full set of numeric standards. This segmentation and these standards were adopted by the Colorado Water Quality Control Commission (WQCC) in 1990 and reaffirmed in November 1995 and the temporary modification was extended for five years. An aquatic biological assessment of the stream system was prepared for that hearing which documents several years of biological survey information. The report documented brook, brown and rainbow trout; kokanee salmon, longnose and white

suckers in Segment 6b (Chadwick 1995). It was suspected they might have been transient from the water diversion structures. Above the road, due to poor habitat and low flow, the stream was determined to not consistently support fish.

Three Lakes Water and Sanitation District (District) provides services to the community of Grand Lake including the residential areas surrounding Grand Lake, Shadow Mountain Lake and Lake Granby. The wastewater treatment plant (WWTP) discharges treated municipal wastewater near the top of the un-named tributary. Currently, the District operates a lagoon wastewater treatment system with a plant capacity of 1.3 million gallons per day (MGD) or 2 cubic feet per second (cfs). They have initiated a facilities plan for a 2.0 MGD (3.1 cfs) mechanical wastewater treatment plant. The District discharges treated effluent pursuant to its Colorado Discharge Permit System (CDPS) discharge permit no. CO-0037681 to un-named tributary to Willow Creek approximately 1.6 miles above Willow Creek Reservoir Road (discharge point latitude/longitude approximated from mapping software as 40.162138 North/-105.919599 West). The effluent is piped from the third lagoon cell to an outlet point on the un-named tributary to Willow Creek (see Figure 2). The WWTP currently has no ammonia limit, but through a stipulated agreement with the Colorado Water Quality Control Division (WQCD), they monitor total ammonia, pH and temperature on a weekly basis.

II. WATER QUALITY STANDARDS

Table 1 presents the water quality classifications and ammonia standards for Segments 6b and 6c. This information was extracted from the Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River, WQCC Regulation No. 33, effective date: November 1999 (WQCC 1999A). Segment 6b only has numeric standards for DO, pH and fecal coliforms. Segment 6c has the full set of physical/biological, inorganic and metals numeric standards. Ammonia is the only parameter listed as impaired on the 303(d) List for Segment 6c and therefore is the parameter addressed in this TMDL.

Table 1

Summary of Stream Classifications and Water Quality Standards

Basin: Upper Colorado River		Desig	Classifications	Numeric Standards (mg/L)	Temporary Modifications and Qualifiers
Stream Segment Description				Inorganic	
6b	Mainstem of un-named tributary to Willow Creek from headwaters (Sec 32, T3N, R76W) to Willow Creek Rd. (Sec 8, T3N, R76W)	UP	Aq Life Cold 2 Recreation 2 Agriculture		
6c	Mainstem of un-named tributary to Willow Creek from the Willow Creek Reservoir Road (Sec 8, T3N, R76W) to the confluence with Willow Creek (Sec 8, T2N, R76W)	UP	Aq Life Cold 2 Recreation 2 Agriculture	NH_3 (ac)=TVS NH_3 (ch)=0.02	NH_3 (ac/ch) = ambient (effective until 12/30/00)

The first column in Table 1 is the segment number. The segment is also identified by it's Waterbody Identification (WBID), COUCUC06b, or "CO = Colorado, UC = Upper Colorado River Basin (Major basin), UC = Upper Colorado River Basin (Sub-basin), 06b = Segment Number". The segment description follows in the second column. Column 3 describes the Designation which determines the antidegradation requirements for the segment. Both Segments 6b and 6c are designated Use Protected (UP) meaning antidegradation reviews are not required. The fourth column consists of Use Classifications (Aquatic Life, Recreation, Agriculture, Water Supply). Both these segments are classified for cold water aquatic life class 2, recreation class 2 and agriculture uses. Column 5 contains the acute and chronic unionized ammonia (NH_3) standards. Segment 6b does not have unionized ammonia standards and Segment 6c has an acute standard of TVS and a chronic standard of 0.02 mg/L as N. The final column lists the temporary modifications adopted for the segment. Segment 6c has a temporary modification to the ammonia standard set at current ambient water quality and expires on 12/30/2000.

The form of ammonia that is toxic to aquatic life is unionized ammonia. The conversion of total ammonia to the unionized form is a function of the pH and temperature. High pH and temperature create more toxic conditions. Ammonia standards are in the form of unionized ammonia, in mg/L as N. The acute ammonia standard for Segment 6c is TVS which are found in "The Basic Standards and Methodologies for Surface Water", WQCC Regulation No. 31 (WQCC 1999B). The acute TVS for ammonia is an equation in which the ammonia standard is a function of pH and temperature. The acute TVS equation is presented in Appendix A. Analytical laboratories can not measure unionized ammonia therefore source concentrations and loads of ammonia are expressed in terms of total ammonia.

III. PROBLEM IDENTIFICATION

In 1990, the un-named tributary to Willow Creek was divided into two segments to recognize differing water quality conditions. A temporary modification for ammonia was established for Segment 6c. The temporary modification was set at ambient levels to reflect existing condition of discharges from the District and agricultural activities. This allowed the District time to conduct monitoring and determine possible treatment required to meet underlying TVS. In 1993 and 1994 the temporary modifications were extended to allow the District to continue sampling and collecting data on Segment 6c. When temporary modifications were extended in 1994, the Commission also scheduled a rulemaking hearing for November 1995 to consider revisions to the use classifications and/or water quality standards for the segments. As a result of the testimony presented at the hearing, the Commission re-affirmed the underlying ammonia standards and extended the temporary modifications for five additional years, with the understanding that the District would continue data collection and would start planning for plant upgrade.

The decision to list Segment 6c on the 1998 303(d) List was based on temporary modifications of the ammonia standards. Additionally, both the acute and chronic unionized ammonia standards are exceeded. Analysis of water quality data from 1993 to 1999 indicates that the ambient unionized ammonia concentration of 0.044 mg/L (out of 229 samples) exceeds the chronic standard of 0.02 mg/L (WQCD 1999).

IV. WATER QUALITY GOALS

The desired endpoint of this TMDL is the attainment of the underlying unionized ammonia standards for Segment 6c including the following goals:

Goal no.1: 0.02 mg/L unionized ammonia as N instream concentration (evaluated as the 85th percentile of ambient data not to be exceeded more than once in 3 years)

Goal no.2: Acute standard calculated by the TVS equation attained as instream concentration (evaluated as a single sample or one day average concentration not to be exceeded more than once in 3 years)

Post-Implementation monitoring to demonstrate attainment of goals is discussed under Section VII, TMDL Allocation.

V. SOURCE ANALYSIS

The development of this TMDL must include an identification of all potential pollutant sources. The contributing watershed to the Segment 6c portion of the un-named tributary to Willow Creek is a small and well-defined area. The evaluation of sources is presented below.

Ammonia Sources: In order to analyze the sources of ammonia to the un-named tributary, the realm of potential sources of ammonia in Colorado surface waters was evaluated. These include: point source discharges (discharges of pollutants from a pipe or other discharge structure), nonpoint source discharges (diffuse discharges across a broad reach of stream) and natural background levels. Nonpoint sources could include contributions from animal waste and leaking septic systems. Natural background sources might only include contributions from animal waste associated with wildlife and decomposing plant life. Groundwater sources might only include those waters hydrologically connected with the surface water and containing pollutants from leaking septic systems.

Un-named tributary Ammonia Sources: The potential ammonia sources for Colorado surface waters were then evaluated for the un-named tributary watershed. These include: the Three Lakes Water and Sanitation District discharge (point source), animal waste from the grazing cattle and occasional wildlife (nonpoint source) and decomposing plant life. The contributions from animal waste and decomposing plant life could be considered negligible (less than one percent of total new load) when compared to the contributions from the WWTP discharge. There are no septic systems in the un-named tributary watershed and therefore were eliminated as a source. The only significant source of ammonia is from the WWTP.

VI. TECHNICAL ANALYSIS

A low flow evaluation, source assessments and modeling were utilized to determine the maximum ammonia load to Segment 6c to attain standards.

Hydrology: Generally, concentrations of pollutants in surface waters are indirectly related to flow. The higher the stream flow, the lower the concentration and the lower the stream flow, the greater the concentration. Therefore, the low flow condition instream becomes the critical condition for the analysis and for the survival of aquatic life. This ammonia TMDL is developed for the protection of aquatic life. The District has measured flow of the discharge and instream at Sampling Point B from 1993-1999. Daily effluent flows were subtracted from flows at Point B to determine the daily flows at Point B without the influence of the WWTP. The acute (one day in three year interval) and chronic (30 day average in three year interval) low flows were then calculated. The annual and monthly acute (1E3) and chronic (30E3) low flows at Point B upstream of Segment 6c are presented below in Table 2.

Table 2
Low Flows for un-named tributary to Willow Creek (cfs)

	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1E3	0	0	0	0	0	0	0.7	1.1	0	0.2	0	0	0
30E3	0	0	0	0.2	0.1	0.5	0.7	1.8	0.4	0.6	0.1	0	0

Source Assessment: The principal load to Segment 6c was determined to be from the District WWTP. The contributions from animal waste and decomposing plant life could be considered negligible (less than one percent of total load) when compared to the contributions from the WWTP discharge.

WWTP Source Contribution: The current WWTP discharges up to 29 mg/L total ammonia. These loads must be reduced in order to meet standards. The necessary reduction in load to attain stream standards is detailed in Section VII, TMDL Allocation.

Animal Waste Source Contribution: Anecdotal evidence and site observances indicate that cattle in the Willow Creek Reservoir vicinity do not graze in the un-named tributary watershed. As a conservative measure, loads from occasional cattle grazing were estimated in the TMDL analysis. A rate of 1.1 mg/L total ammonia for 200 animal unit days per hectare was used to compare to the un-named tributary site (CSU 1999). One cow per acre was estimated to graze in one third of the watershed for five percent of the grazing season (late spring to early fall). The resulting monthly load of total ammonia from the occasional grazing cattle was estimated at 0.005 mg/L total ammonia.

Natural Background Source Contribution: Loads from decaying plant life were estimated in the TMDL analysis. The estimated background rate was 0.0005 mg/L total ammonia (CSU 1999). A total nonpoint source and natural background monthly load was conservatively estimated as 0.11 mg/L total ammonia.

Margin of Safety: The MOS used in the TMDL analysis is implicit. Conservative assumptions used in the analysis included the use of the acute and chronic low flows, the maximum pH and minimum temperature of the receiving stream, future discharge at the maximum (design) capacity and conservatively estimated ambient total ammonia loads instream among other assumptions mentioned below. Post-implementation monitoring at instream locations at the top and bottom of Segment 6c is necessary as part of the MOS to provide assurance that standards are attained.

Colorado Ammonia Model: The Colorado Ammonia Model (CAM) was used to determine the allowable concentration of ammonia in the effluent to meet the standards in the receiving stream. CAM uses instream data, effluent data and many variables. Instream pH and temperature data were collected weekly by the District at Point B from 1993 to 1999. Effluent pH and temperature data were estimated for the new facility based on similar plants in the region. Instream flow values were determined from the low flow analysis and the effluent flow was determined as the design capacity of the facility. The values used for the other variables in the model are listed below:

- stream velocity = $0.3Q^{0.4}$
- ammonia loss rate = 6/day
- pH amplitude was assumed to be high
- default times for pH maximum, temperature maximum, and time of day of occurrence
- pH rebound was set at the default value of 0.2 single units (s.u.) per mile
- temperature rebound was set at the default value of 0.7 degrees Celsius per mile.

After reviewing the data collected by the District including pH, temperature and total ammonia of the effluent and the stream at Point B, the WQCD attempted to develop a site-specific ammonia loss rate. Assuming default coefficients for velocity, the loss rate that balanced both under and over estimation was determined to be approximately 8/day. In order to minimize underestimating total ammonia concentrations downstream, this loss rate was reduced to 6/day which is also the default value (CU 1999). An ambient concentration of total ammonia instream was conservatively estimated as 0.11 mg/L.

Several model runs were completed with different inputs. The estimated ambient instream total ammonia concentration resulted in the same model outputs as a zero ambient concentration. The low flows had been calculated as zero for most of the year. For the months with flow, the flow was entered both as upstream flow and as tributary flow entering at several locations downstream. The location of the input flow did not effect the model outputs. The results of the modeling are based on the best available information and are provided in Section VII.

VII. TMDL ALLOCATION

Allocation Methodology: The required reduction in load from the WWTP was determined through the use of surface water quality models. The annual TMDL for the stream is based on a LA of 0.11 mg/L (0 lbs/day) total ammonia, a WLA of 6 mg/L (100 lbs/day) total ammonia and an implicit MOS. The annual TMDL is equal to the sum of the LA and WLA. The LA resulted as insignificant in the analysis. The annual WLA for the District WWTP is 6 mg/L total ammonia. The monthly TMDL is presented in Table 3.

Table 3
Waste Load Allocations of Total Ammonia
for WWTP

	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Acute (mg/L)	17	22	22	17	28	25	32	32	25	28	24	19	17
Acute (lbs/day)	284	367	367	284	467	417	534	534	417	467	400	317	284
Chronic (mg/L)	6	7.5	7	6	8	7	9.5	8.5	11	7	6	6	7
Chronic (lbs/day)	100	125	117	100	134	117	159	142	184	117	100	100	117

Implementation: The TMDL will be implemented in the form of a District discharge permit limit for total ammonia. The District has been planning to upgrade for many years; the new facility will provide better treatment. The District is on the WQCD Projects List (list of all projects), Short List (list of projects to be funded in the year 2000) and Eligibility List (list of projects in the planning stages) prioritizing them for funding for construction.

Post Implementation Monitoring: In order to insure that the TMDL is adequately protective of the entire segment, post implementation monitoring is required. The new permit for the District should include a monitoring schedule consisting of frequent (weekly or biweekly) sampling for pH, temperature; and total ammonia. The sampling locations are identified on Figure 3 and include sampling the effluent; and un-named tributary to Willow Creek at Point B and above the confluence with Willow Creek.

Attainment of standards should be measured at the top of Segment 6c (i.e. in un-named tributary to Willow Creek at the road) and the bottom of Segment 6c. Attainment will be evaluated at the end of the four year period beginning at the time the new Three Lakes WWTP becomes fully operational. This allows time for the facility operators to determine the optimal operating efficiency and then a three year period to determine whether the standard is being attained.

VIII. PUBLIC INVOLVEMENT

The public has had the opportunity for involvement since the early 1990's when the un-named tributary was proposed for re-segmentation in the Upper Colorado Regulation No. 33. The WQCC hearings held over the years regarding the un-named tributary have been conducted as a public process. In addition, the compilation of the 303(d) Lists has been a public process.

This TMDL was first presented to the District Board of Directors public meeting in Grand Lake on August 5th, 1999. A public meeting was held in Denver on January 25th, 2000 to provide an update on the status of several TMDLs in development including the un-named tributary to Willow Creek Ammonia TMDL. A sign-up list was posted at this meeting for those interested in receiving updates on the TMDL. In addition, WQCD field personnel have been interacting with the local community on these issues for several years including the Upper Colorado Watershed Coordinator and the Grand County District Engineer.

The public notice period for this TMDL was from March 2nd to April 2nd, 2000. Copies of the TMDL were sent to those who signed up at the January public meeting. The TMDL was noticed in several publications including: the Colorado Statesman and WQCD Water Quality News Bulletin. The TMDL and associated fact sheet were posted on the WQCD web page.

The WQCD received comments from the District consisting of the following:

The Three Lakes W&S Wastewater Treatment Plant will be an activated sludge extended aeration treatment process. The process will nitrify, thus using 7.2 lb alkalinity as CaCO3 for every pound of ammonia converted to nitrate. The influent alkalinity will be relatively low, typically below 100 mg/L as CaCO3. It has been RTW's experience that plants with these conditions produce an effluent pH in the 6.5 to 6.9 range. Our operating goal for the Three Lakes plant will be effluent pH 6.8. Please run the ammonia model using the pH 6.8 value for plant effluent.

The inputs to the ammonia modeling were altered to reflect the expected effluent pH. The results of the modeling were then incorporated into the TMDL.

The WQCD also received comments from Earth Justice Legal Defense fund consisting of the following:

Comment 1: *First, the Summary of Rationale ("SOR") for the TMDL indicates that the Three Lakes Water and Sanitation District (the "District") represents the only significant source of Ammonia to the Tributary. The SOR notes that animal waste from cattle grazing may also contribute Ammonia, but treats it as "negligible" based on "anecdotal evidence" that cattle do not graze in this watershed. Please explain the source of this evidence, and whether the Division monitored land use in the area to confirm this assumption.*

Similarly, the SOR notes that leaky septic systems may also be a source of Ammonia. However, the SOR never analyzes whether such septic systems contribute Ammonia to the Tributary. Please explain the reason for this apparent omission.

Comment 2: *The SOR also notes that the toxicity of Ammonia increases with temperature. Yet the SOR later states that the Division assumed the 'minimum temperature' of the Tributary as a conservative assumption for the TMDL's Margin of Safety. If Ammonia's toxicity increases with temperature, it seems that a conservative TMDL assumption would instead use the maximum stream temperature. Please explain why a minimum temperature was used.*

Comment 3: *The SOR also notes that the Tributary has a low flow of zero for nine months out of the year; and the District's effluent is assumed to represent the Tributary's entire flow during these months. As a result, virtually the entire TMDL is allocated to the District [5]. In months where the Tributary has no flow to dilute the District's Ammonia discharge, it would appear that the District's wasteload allocation should itself comply with WQSs. But the applicable WQS for Ammonia is stated in terms of unionized Ammonia, and the SOR only lists the District's WLA in terms of total Ammonia. The TMDL would be clearer if it described the WLA in terms of unionized Ammonia [6].*

Moreover, it is not clear from the SOR why the District's wasteload allocations are larger in zero-flow spring and summer months than in other zero-flow months. If Ammonia toxicity increases with temperature, it would seem that the District's wasteload allocation should be smaller in warmer months than in colder months (assuming no in-stream flows to dilute the District's effluent). Please explain this apparent discrepancy.

Footnote 5: If a meaningful number of cattle graze in the Tributary's watershed, their wastes would most likely reach the Tributary in stormwater runoff. In that case, low stream flow situations may not represent the "critical condition" for Ammonia in the Tributary.

Footnote 6: Alternatively, the SOR could also include limits on pH and temperature, as these determine the amount of unionized Ammonia found in a given level of total Ammonia.

Response 1, Paragraph 1: Contributions from animal waste were calculated as less than one percent of the total load and therefore could be "considered" negligible. The contributions were estimated at 0.0005 mg/L and 0.005 mg/L total ammonia for decomposing plant life and animal waste, respectively (See Section VI, Technical Analysis). A total concentration from nonpoint and background sources was then conservatively estimated at 0.11 mg/L total ammonia in the ammonia analysis (see Section VI, Technical Analysis). **The statements of nonpoint source loads "are considered negligible" when compared to the point source load, have been changed to "could be considered negligible" to clarify that they were estimated and included in the analysis.**

The anecdotal evidence was obtained from personal correspondence with Three Lakes Water and Sanitation District representatives. These personnel are most familiar with this small watershed due to their location within it. In addition, WQCD personnel observed marshy conditions in most of the lower watershed and steep hillsides in the upper watershed which are undesirable for cattle grazing. WQCD personnel observed no visual grazing or impacts from grazing.

Response 1, Paragraph 2: Leaking septic systems could be a source of ammonia in Colorado surface waters. There are no septic systems in the small watershed and were therefore excluded as a source of ammonia in the un-named tributary. **A statement clarifying the lack of septic systems has been added to the text of Section V, Source Analysis.**

Response 2: The analysis of ammonia toxicity as it is transported downstream is a complicated one. Total ammonia decreases downstream due to several processes and the unionized fraction changes based upon pH and temperature. Simple calculations are not adequate and therefore, in 1991 the WQCD hired James F. Saunders, III and William M. Lewis, Jr. of the University of Colorado to develop the Colorado Ammonia Model (CAM). The model was recently expanded and modernized in 1999. CAM analyzes ammonia toxicity on a site-specific basis. There are many variables used in the model which effect model outputs including flows, pH, temperature and loss rates (see Section VI, Technical Analysis for larger list).

Temperature effects the unionized fraction of total ammonia (or the toxicity of ammonia) and the loss rate of total ammonia. Higher temperatures increase the fraction of unionized ammonia and therefore increase ammonia toxicity. Higher temperatures also increase the rate at which total ammonia is degraded. Model inputs of high instream temperature would increase the fraction of unionized ammonia at the discharge point but would also increase the rate of total ammonia loss as it travels downstream.

In the case of the un-named tributary to Willow Creek, the discharge point is located on Segment 6b which has no ammonia standard. Instream ammonia concentrations must meet standards in Segment 6c which is located downstream. The stream temperature rebounds downstream in Segment 6c thereby having little effect on the unionized fraction, therefore for the temperature component, the loss rate of total ammonia becomes more controlling. A lower temperature resulting in a slower rate of ammonia degradation was therefore the more conservative assumption.

The instream temperature only had an effect on model outputs during the summer months when there was more flow instream. Different model runs were completed with different assumptions. The most conservative assumptions were used collectively for determining the Total Maximum Daily Load (TMDL) including the minimum instream temperature.

Response 3, Paragraph 1: In months with low flow of zero, the District's effluent would have to comply with water quality standards. Note the only standards adopted for Segment 6b are dissolved oxygen, pH and fecal coliform (see Section II, Water Quality Standards). There are no ammonia standards for Segment 6b. The effluent must therefore meet standards downstream in Segment 6c. The distance from the discharge point to the top of Segment 6c is 1.6 miles (Section I, Introduction). Concentrations of total ammonia decrease in this stretch of river. The amount of allowable total ammonia in the effluent is based on meeting the unionized ammonia standard throughout Segment 6c.

The Segment 6c ammonia standard is expressed as unionized ammonia which is the portion of total ammonia that is toxic to aquatic life. Analytical laboratories can not measure unionized ammonia. The fraction of total ammonia that is unionized is calculated as a function of pH and

temperature (Section II, Water Quality Standards). The unionized fraction changes throughout the time of day as the instream pH and temperature change. Discharge permit limits for ammonia are expressed as total ammonia which is a measurable quantity. The TMDL and associated allocations are expressed as total ammonia which is measurable and predictable throughout the stream. **A statement has been added to Section II, Water Quality Standards, clarifying that unionized ammonia can not be measured and therefore loads are expressed as total ammonia.**

Response 3, Paragraph 2: The toxicity of ammonia varies downstream of a discharge due to total ammonia loss, flow and varying pH and temperature. The model incorporates many variables which effect the outputs (See Response to Comment 2 above). The waste load allocations are generally higher in the months with flow but are dependent on too many factors to single out a driving factor. The warmer temperatures will cause the amounts of total ammonia to decrease at a faster rate. The TMDL is based on the most stringent concentrations of total ammonia. The concentrations are for chronic conditions (see Table 3, Section VII, TMDL Allocation). The chronic low flows vary from zero to two cfs with minimal flow from March to October (see Table 2, Section VI, Technical Analysis). For chronic conditions that drive the TMDL, there is minimal flow in most months.

Response 3, Footnote 5: The contributions from cattle grazing are minor when compared to those from the wastewater treatment plant (WWTP) effluent. At high flow the amount of allowable ammonia in the discharge would increase due to dilution. The contributions from cattle grazing at high flow would still be minor when compared to the discharge from the WWTP effluent.

Response 3, Footnote 6: Covered under Response 3, Paragraph 1.

IX. REFERENCES

WQCC 1998: Colorado Department of Public Health and Environment, Water Quality Control Commission, 1998 303(d) List of Impaired Waters, 1998.

WQCC 1999A: Colorado Department of Public Health and Environment, Water Quality Control Commission, Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12), Regulation No. 33, Amended November 30, 1999.

WQCC 1999B: Colorado Department of Public Health and Environment, Water Quality Control Commission, The Basic Standards for Methodologies for Surface Water, Regulation No. 31, 5 CCR 1002-31, Amended March 3, 1999.

Chadwick 1995: Chadwick Ecological Consultants, Inc., Aquatic Biological Assessment of an Un-named Tributary to Willow Creek, Grand County, Colorado, June 1995.

WQCD 1999: Colorado Department of Public Health and Environment, Water Quality Control Division, Written Testimony for Regulation No. 33 Triennial Review Rulemaking Hearing, Exhibit No.2, July 1999.

CU 1999: Saunders, Sjodin and Lewis, University of Colorado, Cooperative Institute for Research in Environmental Sciences, Center for Limnology, The Colorado Ammonia Model, Release 3, May 1999.

CSU 1999: Trlica, Nibarger, Leininger and Frasier, Runoff Water Quality from a grazed montane riparian ecosystem, Proceedings from VI International Rangeland Congress, Australia, July 1999.

Figure 1
Un-named Tributary to Willow Creek
Ammonia TMDL
Locational Map